

## **Collection of LAI and FPAR Data over the Terra Core Sites**

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### **FINAL TECHNICAL REPORT: SEP/01/1999 – AUG/31/2000**

The objective of our effort was to collect and archive data on LAI (leaf area index) and FPAR (Fraction of Photosynthetically active Radiation absorbed by vegetation) at the EOS Core validation sites as well as to validate and evaluate global fields of LAI and FPAR derived from atmospherically corrected MODIS (Moderate Resolution Imaging Spectrometer) surface reflectance data by comparing these fields with the EOS Core validation data set. The above has been accomplished by

- (a) the participation in selected field campaigns within the EOS Validation Program;
- (b) the processing of the collected data so that suitable comparison between field measurements and the MODIS LAI/FPAR fields can be made;
- (c) the comparison of the MODIS LAI/FPAR fields with the EOS Terra Core validation data set.

#### **Summary of work performed**

- Participation in the SAFARI 2000 wet season field campaign (Mar. 3 – Mar. 18, 2000). Data needed for validation of the LAI/FPAR product were collected, archived and analyzed.
- Comparison of MODIS LAI with SAFARI 2000 field measurements has been carried out.
- Participation in the Ruokolahti field campaign, Finland, June 10-24, 2000. Data needed for validation of the LAI/FPAR product were collected, archived and analyzed.
- Comparison of MODIS LAI with Ruokolahti field measurements has been carried out.
- Participation in the Harvard Forest field campaign, Massachusetts, July 21-25, 2000. Data needed for validation of the LAI/FPAR product were collected, archived and analyzed.
- Validation of the LAI/FPAR algorithm with data collected at the Harvard Forest LTER site has been performed.

**No inventions resulted from this project**

## SAFARI 2000 Wet Season Field Campaign

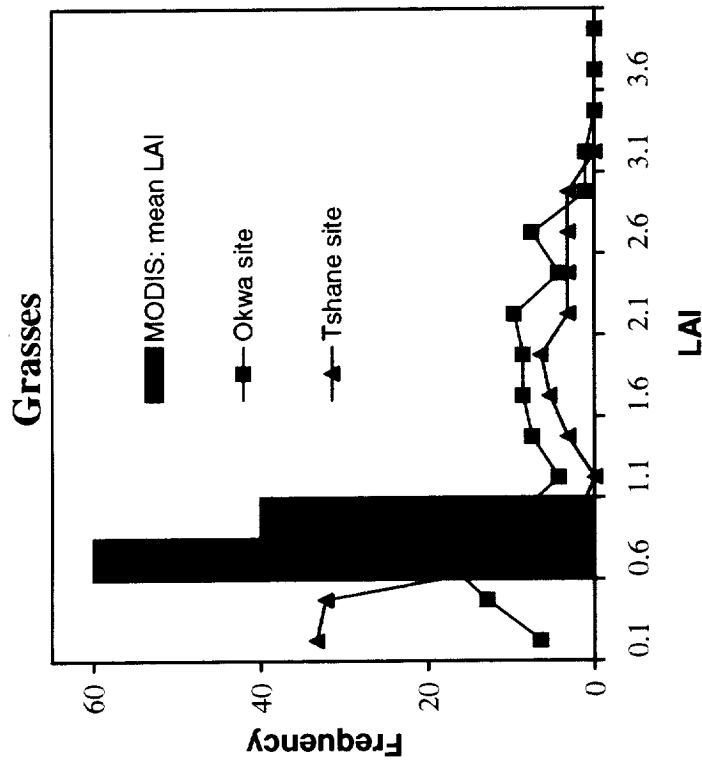
The Boston University team participated in the SAFARI 2000 wet season field campaign, Mar. 3 – Mar. 18, 2000, in collaboration with Dr. Jeff Privette. Our objectives were to obtain LAI/FPAR in the Kalahari transect; validate the MODIS LAI/FPAR algorithm; to describe the spatial variability of LAI/FPAR for the four sites and to investigate the scale effect on LAI/FPAR measurement and retrieval. Ground measurements of LAI, FPAR, leaf and canopy hemispherical reflectance and transmittance were made using the LAI-2000 plant canopy analyzer, AccuPAR ceptometer, LI-1800 portable spectroradiometer and ASD handheld spectroradiometer. LAI/FPAR were intensively measured at 4 different sites, Pandamatenga, Maun, Okwa and Tshane (from north to south in Botswana), where vegetation type ranges from moist closed woodland to arid sparsely-shrub covered grassland. Table 1 lists all the measurements taken during the SAFARI 2000 wet season field campaign. A detailed report on this campaign is available at <http://cybele/modismisr/atbds/atbds.html>. Data are available at our anonymous ftp directory (<ftp://pub/cliveg/ytian/Botswana/lai-measurement/>). Some results are reported below.

**Table 1.** Measurements taken during the SAFARI 2000 campaign

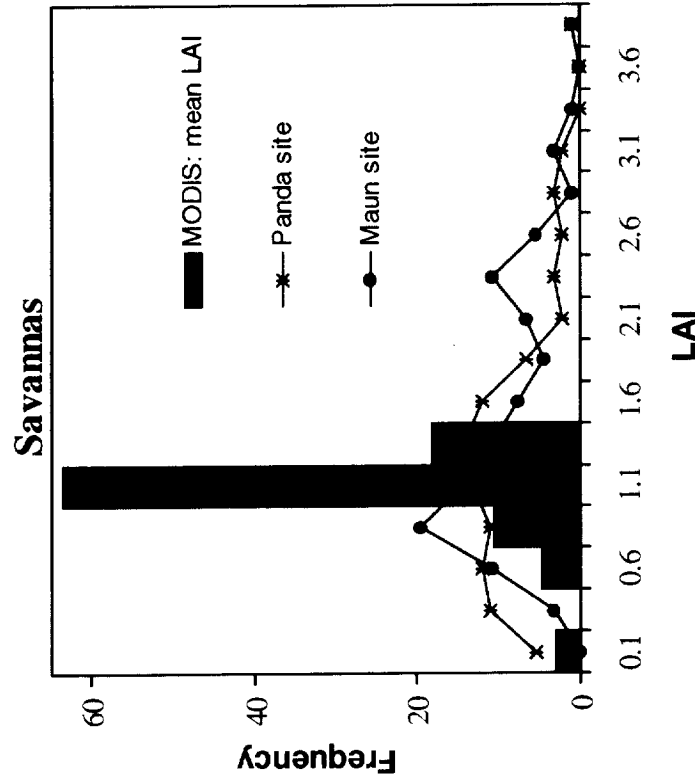
Site	Pandamatenga		Maun		Okwa		Tshane	
Instruments	Transect Scale	Pixel scale	Transect Scale	Pixel scale	Transect scale	Pixel scale	Transect scale	Pixel scale
<b>LAI-2000</b>	+	+	+	+	+	+	+	+
<b>AccuPAR</b>								
Incident flux	+	+	+	+	+	-	+	-
Transmitted flux	+	+	+	+	+	-	+	-
Reflected flux	-	-	-	-	-	-	-	-
Reflected flux from 40 m tower	-	-	+	+	-	-	-	-
<b>LI-1800</b>								
Leaf reflectance, transmittance	+	+	+	+	+	+	+	+
Incident flux	+	-	+	-	+	-	+	-
<b>ASD</b>								
Canopy transmittance	+	-	+	-	+	-	+	-
Under nadir background reflectance	+	+	+	+	+	+	+	+
Canopy reflectance at 30, 45, 60 degree zenith angle	-	-	+	+	-	-	-	-
Under nadir reflectance of individual plant	-	-	-	-	+	+	-	-

+: Measurement was taken; -: No measurements on the site.

# COMPARISON OF MODIS LAI WITH SAFARI 2000 FIELD MEASUREMENTS



	Mean LAI	Dispersion
MODIS	0.70	0.22
Okwa site	1.27	0.80
Tshane site	0.78	0.85



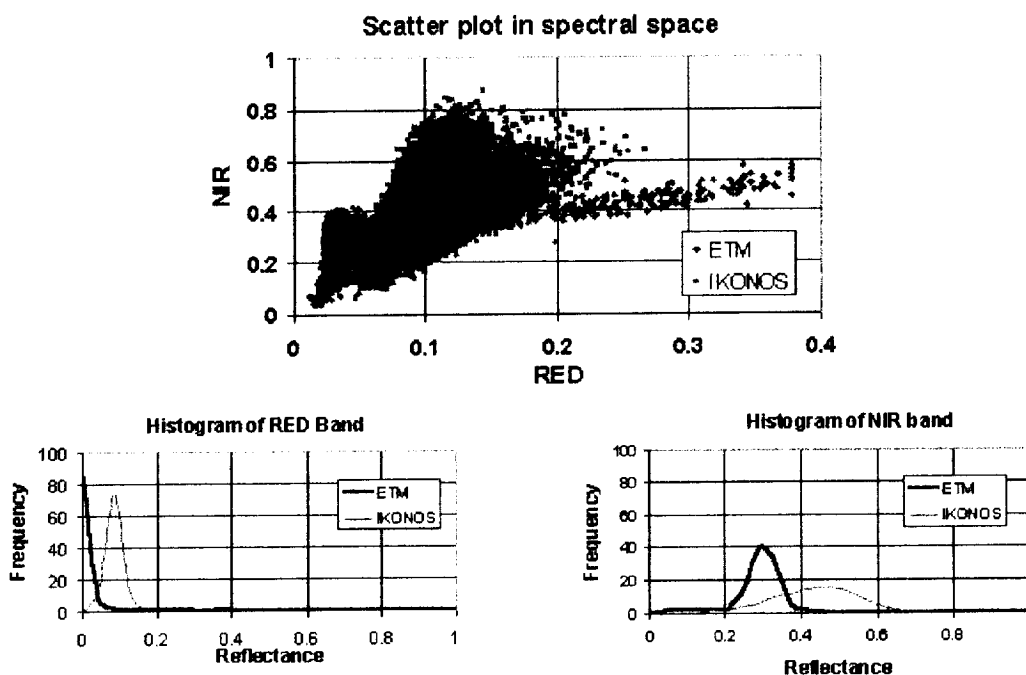
	Mean LAI	Dispersion
MODIS	1.07	0.20
Panda site	1.26	0.78
Maun site	1.50	0.78

**Figure 1.** Figures show the distribution of LAI values derived from field measurements and evaluated with the MODIS LAI/FPAR algorithm. Dispersions derived from field measurements are higher than those derived from MODIS retrievals because the MODIS LAI/FPAR algorithm only accounts for the most probable situations encountered in reality. Mean MODIS LAIs agree with mean LAI values derived from field measurements.

## HARVARD FOREST FIELD CAMPAIGN, MASSACHUSETTS, JULY 21-25, 2000

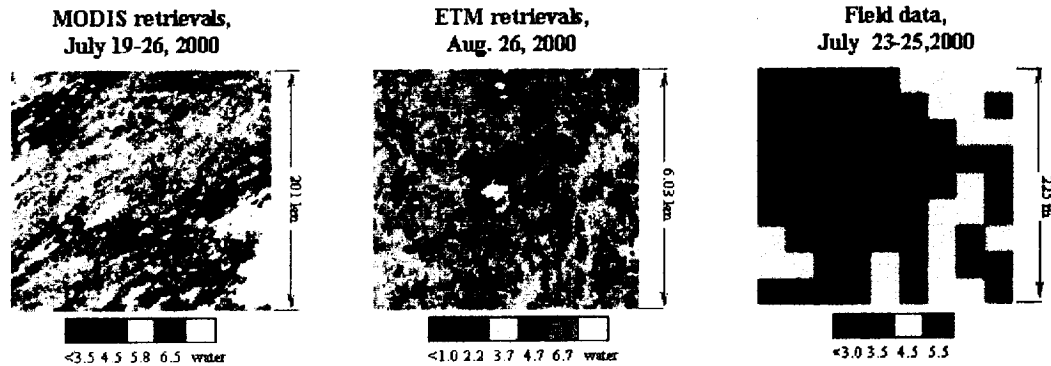
Ground measurements of LAI, FPAR, canopy hemispherical reflectance and transmittance were made using the LAI-2000 plant canopy analyzer, AccuPAR ceptometer, LI-1800 portable spectroradiometer and ASD handheld spectroradiometer. Measurements of leaf optical properties from the dominant overstory species were made at the Harvard Forest LTER site on September 6<sup>th</sup> with the LI-1800 portable spectroradiometer. A detailed report on this campaign is available at <http://cybele/modismisr/atbds/atbds.html>. Data are available at our anonymous ftp directory (ftp: /pub/cliveg/ytian/Botswana/lai-measurement/). Some results are reported below.

### Satellite Reflectance Comparisons



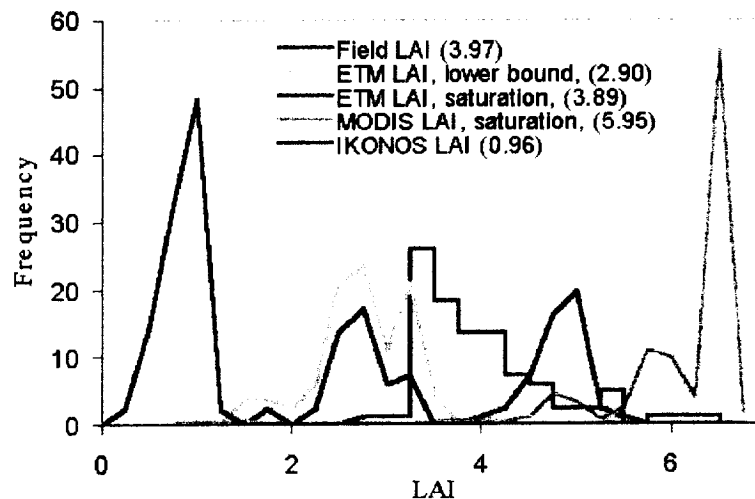
**Figure 2.** Distribution of pixels with respect to their reflectances at near-infrared and red wavelengths derived from the MODIS, ETM LANDSAT and IKONOS surface reflectances (top) and their statistical properties (bottom). The MODIS LAI/FPAR algorithm was applied to these data to produce LAI maps of different resolutions.

## LAI Maps, Centered at Harvard Forest



**Figure 3.** MODIS LAI map for July 21-25, 2000 at 1 km resolution (left). The black square in the center depicts an area of 6 by 6 km where the field campaign was carried out. LAI map of August 26 at 30 m resolution derived with the MODIS LAI/FPAR algorithm using ETM LANDSAT data (center). This 6 by 6 km area is the Harvard Forest LTER site. The location of field measurements is shown as a black square. The right panel shows LAI map at 25 m resolution derived from field measurements (July 21-25, 2000).

## LAI Intercomparison of ETM and Field Data

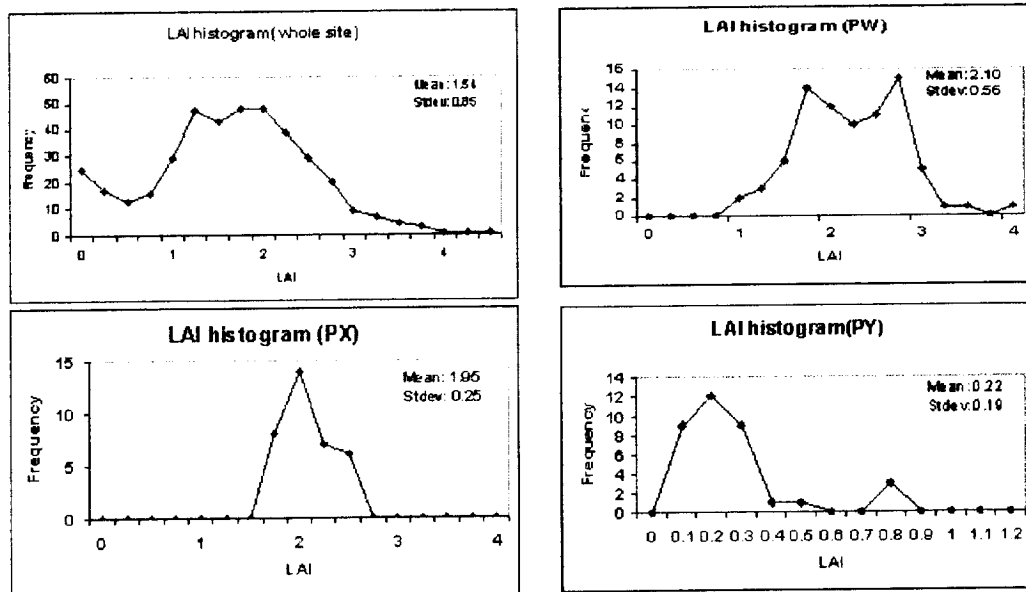


**Figure 4.** Distribution of MODIS LAI and LAI values derived from field measurements and evaluated with the MODIS LAI/FPAR algorithm using ETM LANDSAT data. The MODIS and ETM LANDSAT LAIs were derived under a condition of saturation. The histograms show the upper and lower limits of retrieved LAI values. The mean LANDSAT LAI (3.89) agrees with measured mean LAI value (4.1). The MODIS algorithm overestimates LAI values in the case of a dense canopy.

## RUOKOLAHTI FIELD CAMPAIGN, FINLAND, JUNE 10-24, 2000

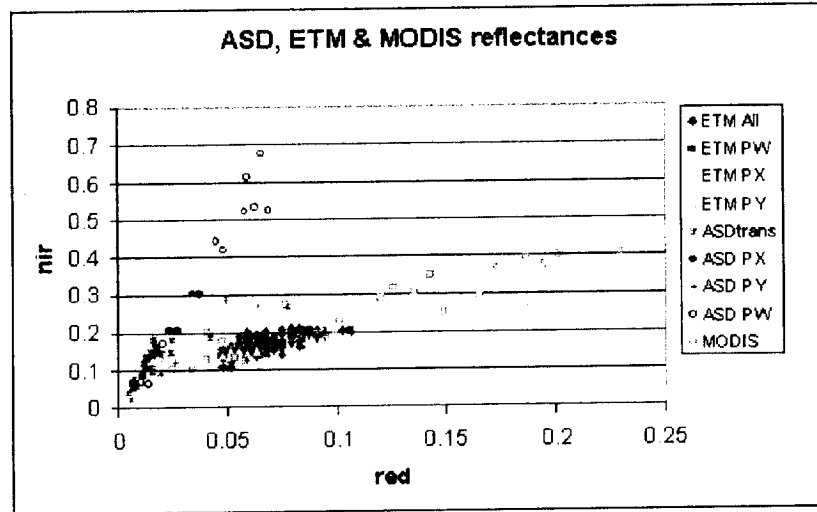
We participated in a field campaign at a needle forest site (mostly pines) near Ruokolahti (61.32°N, 28.43°E) Finland from June 14-21 of 2000 and collected data for validation of the MODIS LAI/FPAR product. During this week, LAI, FPAR, canopy reflectance, canopy transmittance and soil reflectance were intensively measured with LAI-2000 canopy analyzers, ACCUPAR ceptometers, LI-1800 portable spectroradiometer and ASD handheld spectroradiometer. The canopy reflectances, directional and hemispherical, were measured by mounting the ASD on a helicopter. A 1 km site was chosen for intensive ground sampling at a resolution of 50m. Based on a CCD image of the site, the canopy was stratified into three classes (PW, PX and PY) depending on the tree density and age. In these three classes, data were also collected at a higher resolution of 25m in a plot size of 200×200m. The LAI distribution retrieved from the top-of-the-canopy helicopter ASD data and the MODIS LAI product agree well with the field data. A detailed report on this campaign is available at <http://cybele/modismisr/atbds/atbds.html>. Data are available at our anonymous ftp directory (<ftp://pub/cliveg/ytian/Botswana/lai-measurement/>). Some results are reported below.

### LAI Measurement Histograms



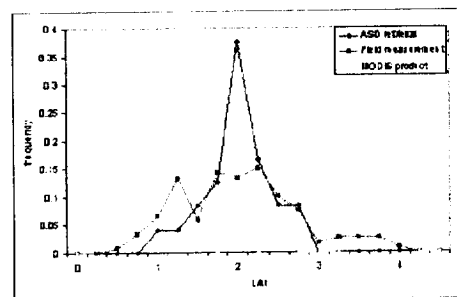
**Figure 5.** Distribution of LAI values derived from field measurements for three canopy classes.

## Measured and Remotely Sensed Reflectances



**Figure 6.** Distribution of pixels with respect to their reflectances at near-infrared and red wavelengths derived from the MODIS, ETM LANDSAT and helicopter ASD. The MODIS LAI/FPAR algorithm was applied to these data to produce LAI maps of different resolutions.

### LAI distribution for algorithm retrieval and field measurements



	Mean	Stdev
ASD retrieval	1.87	0.12
Field measurement	1.89	0.73
MODIS product	2.2	1.40

**Figure 7.** Distributions of LAI retrieved from top-of-the-canopy ASD data, the MODIS product and field measurements at the Ruokolahti needle forest experimental site. The LAI distribution retrieved from the top-of-the-canopy helicopter ASD data and the MODIS LAI product agree well with the field data.